Linear stability of equilibria with magnetic island chains according to a reduced four-field model and to 2 1/2 D Hall incompressible magnetohydrodynamics

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Abstract

We investigate the linear stability of plasma equilibria exhibiting a chain of magnetic islands described by the classical "cat's eyes" solution. The analysis is based on the Energy-Casimir method, limited to formal stability (which implies linear stability), and makes use of a four-field reduced model assuming cold ions and anisotropic equilibrium electron temperature. In particular, this four-field model extends a previous two-field model (Granier and Tassi, J. Phys. A: Math. Theor., 53:385702 (2020)) by including evolution equations for ion gyrocenter velocity fluctuations along the direction of a strong guide field, as well as ion gyrocenter density fluctuations. Two sets of sufficient conditions for linear stability are derived, setting bounds on equilibrium electron temperature anisotropy, the ratio between equilibrium perpendicular electron pressure and the magnetic pressure, the number of islands, their width and the gradient of the ion gyrocenter velocity along the guide field. Taking advantage from a formal analogy, as a by-product of the analysis of the four-field model, we also obtain sufficient conditions for linear stability of equilibria with chain of magnetic islands for 2 1 / 2 D Hall incompressible magnetohydrodynamics.

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